ESSAY

ON THE

CONSTRUCTION AND USE

OF A

MINE-AUGER.

TO WHICH ARE ADDED,

The Deſcription of an Earth-Borer,

FOR

COUNTRY GENTLEMEN AND FARMERS;

AND AN IMPROVEMENT ON THE

WELL-BORER OF MERSENNUS.

ILLUSTRATED WITH COPPER-PLATES.

TRANSLATED FROM THE GERMAN OF Mr. GEISS,

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BRITISH MUSEUM

TO THE

RIGHT HONOURABLE AND HONOURABLE

THE

DUBLIN SOCIETY,

THIS

ESSAY FROM THE GERMAN,

IS

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BY THE

TRANSLATOR.


BRITISH MUSEUM

PREFACE

OF THE

TRANSLATOR.

THE eagerneſs with which mines have been at all times ſought, is proof enough of their importance to mankind. Some indeed were eventually diſcovered for our misfortune; but, without others, the world muſt have been miſerable, agriculture would be impracticable, commerce would languiſh, and the arts remain ſtill unborn.

The inſtrument which is the ſubject of the enſuing eſſay, is calculated to bring us more acquainted with them, and ſupply our conſtant conſumption by the diſcovery of freſh veins. Although the greateſt number of mines, and theſe the richeſt too, have been brought to light by chance only; yet it were very unworthy of the ſpirit of enquiry and enterprize, that, to

the honour of ſcience, animates the preſent generation, to reſt content with ſuch precarious reſources. The obſervations of natural hiſtorians to aſcertain their preſence by the mere outward appearance of mountains, are little more to be relied on: nevertheleſs I do not think them quite uſeleſs, but where they apply, ſufficient to warrant a trial which may be made at ſo trifling a coſt as with this inſtrument. An attentive examination of the beds of ſuch ſtreams as run from mountains, and of the waters themſelves, will often afford a very probable conjecture about their contents: as alſo an examination of the ſtrata, wherever the ſide of the mountain is bare. Some obſervations tend to ſhew that mines are generally on the confines of primeval and ſecondary mountains, but they are alſo ſometimes found in granite itſelf. It is ſaid, that the dew remains a ſhorter time on ſuch parts as are metalliferous than on others, and that there the graſs is foxy; but if there be any truth in this remark, it is only when the ore is near the ſurface. The ſame holds true of the divining rod. Though the external ſigns

are

are fallacious, it is not ſo with regard to others which we obtain in the courſe of boring, and which not only indicate the preſence of ores, but the very ſpecies of them we are to expect.

Here I muſt recur to the excellent work of Mr. Kirwan, to which indeed I would rather refer, as a knowledge of the entire is neceſſary for an intelligent miner, but that it is already out of print, and that ſome time muſt neceſſarily elapſe before a new edition can appear: of this, however, I hope mineralogy will not be long deprived.

" Mountains that conſiſt of ſtones of " the argillaceous genus, and of the ſixth " compound ſpecies of the ſiliceous genus " *(gnieſs)* are the principal ſeat of metallic " ſubſtances, whoſe ores run acroſs the " ſtrata in all directions *. Homogeneous " ſtratafied mountains are chiefly of the " ſame genus, and likewiſe the ſeat of " ores. When they are covered with

* Mineralogy, p. 376.

" primeval limeſtone *(limeſtone of a gra-*
" *nular or ſcaly texture, in which no animal*
" *veſtiges appear)* the ore is generally be-
" tween the calcareous and the argillace-
" ous-ſtones. Theſe ores run in veins
" and not in ſtrata. The calcareous rarely
" contain any ore, when they do, it is
" either iron, copper, lead or mercury.
" Heterogeneous or compound ſtratafied
" mountains, contain coal, bitumen, petri-
" fications and organic impreſſions, alſo
" ſalts, calamine, gold in the ſandy ſtrata,
" iron in entire ſtrata or neſtways, copper
" in the ſtrata, lead ore ſingly, or mixed
" with copper (it ſometimes ſhoots through
" the ſtrata in ſmall veins) cobalt ore in
" the ſtops, pyrites every where. The
" matrixes of theſe ores are chiefly of the
" calcareous *(laminar, not granular or ſcaly*
" *limeſtone)* or barytic genera, rarely guartz,
" and never mica. Confuſed mountains
" of promiſcuous ſtructure ſcarce ever
" contain any ore †."

Hence it appears, it is only the torch of experiment that can illumine their re-

† Mineralogy, p. 386 & ſequent.

ceſſes ;

ceſſes: their outward appearances are uncertain lights, and for this reaſon have often involved people in the moſt ruinous expence; but at a trifling one, the Mine-auger brings the mineral from its concealment, enables us to explore our precious earths, and encreaſe together private property with the public welfare. It carries up ſpecimens of the different ſtrata through which it paſſes, and may on that account be no leſs uſeful in œconomical purpoſes, by diſcovering manure, and ſources of water. The author of this treatiſe, in the true ſpirit of a German, makes it alſo ſubſervient to that heroic profeſſion, in which, as well as in mining, Germany is ſo pre-eminent. But in nothing is it ſo ſuperior to us as in mineralogy and chymiſtry. There is, however, this in our favour, that beginning at ſo advanced a period of experimental philoſophy, we have their numerous acquiſitions, as lights to guide and ſpare us miſmanagements and errors, otherwiſe unavoidable in the infancy and firſt improvements of every art.

With

With ſuch advantages, it is to be preſumed we will ſoon regain our loſt ground, eſpecially when aſſiſted by the judicious and patriotic exertions of the Dublin Society, together with the learned labours of our Academy. Theſe have already rouſed the people of Ireland from their long and lamentable inattention, and are every day productive of the greateſt benefits to huſbandry, the moſt important of all arts: but our mines form an object of the next magnitude. It is happy for us, perhaps, that they are not repoſitories of gold and ſilver; yet they are ſuch as procure it, and more effectully promote induſtry and ſcience, by yielding in proportion to the intelligence with which they are wrought. To thoſe who look to the advancement of arts, and the diſtribution of wealth, it muſt be highly pleaſing to ſee future Rinmans and Bergmans ariſe amongſt us, by cultivating our mines, and a numerous people flouriſh. Works of this kind enrich the northern parts of Europe, and are a conſiderable ſource of England's proſperity. In the hiſtory of ſuch a revolution it were indeed deſirable to hold even the ſmalleſt place amongſt its abettors: but,

but, though I cannot ſhare much of that ſatisfaction, by ſo ſmall an importation of foreign knowledge; yet as I am acquainted with the language which, of all others, contains moſt information relative to mineralogy, agriculture and chymiſtry, I will be able perhaps, in ſome future publication, to make this acquaintance uſeful to my country. German is little known to the literati here, or even in England, "though it is very neceſſary we ſhould "have perſons poſſeſſed of a competent "knowledge of foreign languages, who "ſhould be attentive to the progreſs of "ſcience abroad, and communicate to "their countrymen all uſeful diſcoveries "as they are made †."

DUBLIN,
No. 118, STEPHEN'S-GREEN,
June 30th, 1788.

† Prieſtley: Preface to the 2d edit. of the Hiſtory of Electricity.

Fig. XXI.

Fig. XX.

Fig. XIX.

Fig. XVIII.

Fig. XXII.

Fig. I.

Fig. II.

Fig. III.

Fig. IV

Fig. V.

Fig. VI.

Fig. VII.

Fig. VIII.

Fig. IX.

Fig. X.

Fig. XI.

Fig. XXIII

Fig. XII.

Fig. XIII.

Fig. XIV

Fig. XV.

Fig. XVI.

Fig. XVII.

CONSTRUCTION AND USE OF A MINE-AUGER, &c.

PART THE FIRST.

Deſcription of a Mine-Auger.

SECTION I.

THIS inſtrument is called a Mine-auger, becauſe it is intended to bore the earth for the purpoſe of finding mines, and reſembles the common auger when its different bits are united, as repreſented, plate I. fig. 22. *m. a.* It is capable of penetrating to the depth of one or two hundred fathoms, or even deeper, through every kind of earth: nay, through ſtone and the hardeſt marble. It conſiſts, like the common auger, of an handle, fig. 22. *m.* a ſhank *zzz.* and a borer *a.*

§. II.

The diameter of the handle muſt always be the ſame, that it may exactly fit the eye *k.* of the upper ſhank-bit, fig. 1. Its length varies from three quarters to one, and even one yard and a half. In proportion to the increaſing depth of the hole, the handle ſhould be lengthened: it will thus more readily enable the miner to overcome the reſiſtance of the ſhank. When ſtones are in the way, it is neceſſary to uſe an handle of one yard and a half, though the depth ſhould be inconſiderable; for a greater force is required to pierce them than the earths. The handle is uſually made of wood; but then it muſt be ſheathed with iron, where it lies in the eye of the ſhank, to prevent it from breaking.

§. III.

The ſhank cannot poſſibly be made out of one undivided piece; and were it even practicable, a ſhank of 100 or 200 fathoms would prove quite unmanageable at the beginning of the work. It muſt, therefore, conſiſt of many bits, moſt of which ſhould be of the length of one fathom, others only one-fourth, one-half, or three-

fourths

fourths of a fathom in length. It is formed by ſcrewing theſe bits ſucceſſively together; and, in withdrawing, it muſt be ſhortened in the ſame order.

§. IV.

The firſt ſhank-bit, fig. 1, is about two yards long, and has at the upper end a ſtrong eye, *k*. through which the handle paſſes: down to *o*. it is round, but ſpreads there, to form a hold for the key, fig. 16, *x*—*y*; by means of this key it is ſcrewed and unſcrewed. Its diameter *t*. *u*. is one inch and a half. It has two protuberances in the middle, *m*. two or three inches aſunder, for faſtening on a rope, or receiving the fork, *a*. fig. 19, on which it reſts when the auger is directed downward. At its lower extremity, *n*. *l*. it is two inches thick, and has a female ſcrew one inch in diameter. The matrix of the ſcrew ſhould have but five windings at moſt, leſt any bent ſhould happen in joining or ſeparating the different *bits*. In caſe of accidents it would be proper to have two or three firſt-ſhank-bits in ſtore.

§. V.

Then follow the other bits, fig. 2. which ſhould be, as already mentioned, of different lengths. The ſhorteſt are firſt employed; when they have bored almoſt to the handle, they ſhould be unſcrewed, and one of a fathom put on, &c. Theſe bits have a male-ſcrew at *p*. by which they faſten in the matrix of the firſt bit *n. l.* or an other, *q*. Like it they are two inches in diameter at the ſcrew, and flattened at *s*. as the other bits under their reſpective ſcrews. Like the firſt one alſo, each is round, and one inch and half in diameter, but widens to two inches at *q*. where a female-ſcrew receives the third, this the fourth, and ſo on.

Of the bits of one-fourth, one-half, three-fourths of a fathom, two or three will ſuffice; but of the fathom-bits, it is neceſſary to have as many as make up the length to which we intend to bore, and eight or ten to the good; that, ſhould one break, another ſhould be at hand to take its place.

§. VI.

Whereas the ſhank cannot conſiſt of one piece, but muſt, on the contrary, be compoſed of many bits, it may eaſily happen that one of thoſe would unſcrew, and be loſt by remaining in the hole: eſpecially when it becomes neceſſary to ſtir the auger back and forward, wherever a great deal of ſandy ſludge falls in from the ſides, and obſtructs its paſſage. To prevent this inconvenience, I contrived a ſcrew-nail, fig. xvii. *b. g.* which paſſes through the matrix and male-ſcrew, *a. a.* and is ſo tightened by its matrix, that the bit cannot poſſibly come out, nor conſequently can the accident happen. Fig. xvii. *b.* is the extracting hook; *c.* is a bit ſcrewed into it, and faſtened by the ſcrew-nail, *a. a.* — *d.* is another bit, ſcrewed into the bit *c.*; and in this manner all the bits, not excepting the ſcoop itſelf, are guarded againſt unſcrewing. Nor is there any danger, as it perhaps may be objected, that the ſcrew-nail will injure the male or female-ſcrew, for it ſhould be ſo ſmall that the requiſite perforation can certainly prejudice neither. Should any one, however, through exceſs of caution be unwilling to employ it,

it, the following, which is ſtill more ſimple, will prove equally effectual. A ſmall hole is made in the bulb of the bits, but not pervious at the bottom, fig. 2. fig. 23; when they are ſcrewed a pin is put into it, *a. b.* fig. 23, *a. æ.* fig. 2. and this will equally prevent their ſeparation. The pin muſt not be very thick, but ſtill ſhould completely fill its bed, leſt it fall out.

§. VII.

It is almoſt needleſs to recommend that the ſcrews of the different bits ſhould be as equal as poſſible. To this end, they ought to be cut by the ſame inſtrument. The variety of ſtrata in the mountain, renders it neceſſary to have ſcoops of various conſtructions. To the common auger there are nine. We will deſcribe them in the order they are uſually employed.

§. VIII.

1ſt. The ſcoop or borer, fig. 4, is calculated for clayey earth: From *n.* to *o.* it is 20 or 22 inches long; from *a.* to *b.* ſix inches broad; from *o.* to *g.* it has a circular cavity, but from *g.* to *n.* it is ſolid iron, and flattened in *e.* for the reception of

of the key. The ſcrew *n.* has been already explained. At *o.* it has a ſharp and open edge; thence to *g.* it has a fiſſure two inches wide, for gathering the earth. Should this be ſo preſſed as not to fall out by a ſtroke, it can be taken away through the fiſſure. As this ſcoop is liable to accidents, there ought to be a proviſion of four or five.

§. IX.

2d. The pointed ſcoop, fig. 3, is adapted to earth of a firmer texture, and mixed with ſmall ſtones and ſand. It is from *a.* to *b.* of the ſame length with the former; the width is alſo the ſame. It only differs in having at *b.* a pointed edge that inclines to a ſpiral. By reaſon of this ſhape it ſeparates, or elſe takes up the little ſtones in its way. Of theſe ſcoops we muſt have five likewiſe.

§. X.

3d. Having bored through earth, mould, clay and ſand, and being arrived at the mine, in order to pierce the ſofter kind of ſtones, we take the ſtone-borer, fig. 5. The length of this inſtrument from *a. b.*

to *f.* is thirteen inches; the breadth, *e. d.* ſix inches. The end, *a. b.* is divided, and on the outſide gradually widens to the middle, thence again decreaſes to the bit. At the ſides, *e. d.* it is very ſharp, and three inches thick in the middle. The edge, *e.* is bent one quarter to the left; and the edge *d.* as much more to the right. The bit is two inches thick, flattened in *c.* for fixing on the key. *f.* is the male-ſcrew, correſponding to the matrix *g.* To this inſtrument all the ſofter ſorts of ſtone will readily yield, and a further progreſs be facilitated.

§. XI.

4th. If hard ſtone or marble intervenes, recourſe muſt be had to the ſecond ſtone-borer, fig. 6. The length from *b.* to *f.* is 13 inches, the breadth from *c.* to *d.* ſix inches. It is ſharp pointed, and from this point to the ſhank, it is armed on both ſides with a cutting edge. Its thickneſs, *e.* is ſomewhat more than half its breadth, that when its edge is worn, there may be matter ſufficient to ſupply another without diminiſhing its due width or conſiſtence. The ſhank is two inches thick, flattened in *a.* and turned in *f.* It muſt be obſerved, that

that the two aforeſaid borers ought to be uſed where ſtone alone is to be bored, and not where ſtrata of ſtone lie on other ſtrata of ſofter earth; for, as their points take no hold of the earth, a crooked paſſage, or ſome other miſchance, might readily be the conſequence of employing them. In theſe circumſtances we muſt recur to another, of which I ſhall preſently ſpeak. Of the two kinds laſt deſcribed, there ſhould be a proviſion of twenty-four; for in one layer it often happens that ten, twelve, ſometimes ſixteen loſe their edge, and, if there was no recourſe in the interval of ſharpening thoſe, the work would neceſſarily be protracted to a tedious length.

§. XII.

In a paſſage only half obſtructed by ſtone, it is beſt to break them by means of the crow, fig. 7: from *a.* to *r.* it is thirteen or fourteen inches long, ſquare at bottom; and from *s. t.* to *r. u.* four inches broad. The four corners are armed with prominent, ſomewhat bent, and tapering points, in order to make the ſtronger impreſſion on the ſtone. From *s. t.* it ſlopes regularly to

the place of the key, and at *t. b.* is only two inches thick. The ſcrew is in *a.* Three or four of theſe bits are required.

§. XIII.

Whenever the ſludge, detached by the three laſt inſtruments, is ſo abundant as to obſtruct their further operation, we muſt uſe the ſhovel-bit, fig. 8. its length, *f. g.* the aperture, *k.* the ſcrew, *f.* are exactly like fig. 4; but the breadth, *h. y.* is a little leſs, that the ſludge may more readily fall into it. At the bottom it is cloſed, in order that the ſludge may accumulate, and not fall out. One or two of this kind is enough.

§. XIV.

In caſe a perſon is not able to take out the ſludge with the former inſtrument, or perceives, on the contrary, that it is only preſſed together by it, the ſecond kind of ſhovel-bit, fig. 9. will be found to anſwer every uſeful purpoſe. This inſtrument may be twenty-two inches long. The breadth, *x. y.* is the ſame as that of the reſt. At its lower end, *w.* it is obliquely open and ſharp-edged, ſo as to ſtir up and collect

collect the ſludge into its cavity. One of its ſides is whetted, and laps over the other, *b*:—*f*. is the place of the key, and *u*. is the ſcrew. When the inſtrument is quite full, and that its contents do not readily paſs through the bottom, they may be partly obtained through the ſquare hole *z*. By means of this inſtrument the channel can be cleaned to its bottom, and, as it carries up ſpecimens, we may diſcover the preſence of minerals, coal, &c. and at the ſame time their goodneſs. It is requiſite to have two of theſe inſtruments.

§. XV.

8th. But if the earths detached by the auger are borne up by the eruption of the ſubterraneous waters, no one of the aforeſaid inſtruments will ſerve. The fitteſt in this caſe to take up the ſludge is repreſented by fig. 10. Its length and breadth are exactly ſimilar to fig. 8. and it only differs in being cloſed from its lower part, *c*. to its middle, *m*. but from this to *b*. it has a fiſſure like the other ſhovel-bits, to receive the ſludge and water. One of this kind is ſufficient.

§. XVI.

9th. The laſt inſtrument is deſigned to clear the hole to the very bottom, where this is requiſite. It is repreſented by fig. 11. biſected longitudinally from *i. h.* to the bottom. In length and breadth it reſembles the foregoing. *a. b. c. d.* repreſents half the cavity. *a. c.* and *b. d.* are two ſhelves; *e. f. g.* a piſton that paſſes through them, and whoſe ends at *e.* and *f.* exactly cloſe their coreſponding holes. *i. h.* is a vault pierced by two or three ſmall holes, to emit the air that the riſing water compreſſes. In this vault is a ſpring that drives down the piſton, *e. f. g.*: *k.* is the ſcrew, *z.* a ſmall hole for the ſcrew-nail. When this inſtrument is put into the bored hole and reaches the ground, the reſiſtance oppoſed to the point *g.* forces up the piſton, and the water enters: when the inſtrument is raiſed, the ſpring, being no longer counteracted, depreſſes the piſton, and thus the contents are incloſed and taken up. Both halves of this inſtrument muſt be ſcrewed tight together at *a. c.* and *b. d.* in order to let out no part of its contents, and at the ſame time to render it eaſier to clean or mend, by having a power of opening it.

§. XVII.

In the ſame order that all theſe inſtruments and bits are put together, they muſt, when requiſite, be unſcrewed and taken aſunder. At each time of withdrawing the auger, to paſs the rope, by which this is effected, through the eye of the ſhank, would prove too tedious an operation, becauſe the handle ſhould as often be taken out and put in. To remedy this inconvenience, is the inſtrument, fig. 12. from *a.* to *b.* ſeven or eight inches long, and hooked above to catch the rope. *e.* is the place of the key, where it is one inch thick, thence gradually enlarges to *c. d.* where it meaſures two inches. From *b.* to *z.* is the female-ſcrew, with a ſmall hole for the ſcrew-nail. The bits may be ſcrewed into this matrix, and, as often as neceſſary, the whole ſhank drawn out of the hole. It is proper to have two or three of theſe hooks.

§. XVIII.

Although the precautions here mentioned will prevent any of thoſe bits from unſcrewing, yet it is poſſible one or other of them

them may break. To bring up this, and the other bits adhering to it, is the uſe of two inſtruments next to be deſcribed.

1. The *ſeeker*, fig. 13, is ſeven or eight inches long; *o.* is the ſcrew, *e.* the place of the key; *p.* is a ſpiral point that either takes the broken bit into its cavity, or at leaſt detaches it from the ſide of the hole. One or two of theſe will ſuffice.

§. XIX.

If the *ſeeker* fail, we muſt have recourſe to the *cone-ſcrew*, fig. 14. From *k.* to *l.* it is nine inches long. The aperture, *n. l. o.* is ſix inches wide, and the brim ſharp. It grows narrower to *m.* where is placed a female ſcrew, *x.* It has a ſcrew at *k*, and is faſtened like the reſt juſt below it. As ſoon as the broken bit comes under the mouth of this inſtrument, we work it on until the ſcrew has taken a firm hold, and then quietly draw out the entire. It is neceſſary to have three more of theſe.

§. XX.

There is but one accident more for which we have not already provided: this is

is the falling of the ſhank back into the hole, when we unſcrew any part of it: but, let it be ever ſo long and heavy, it can be ſupported by the cloſed ſhears, fig. 15. Its entire length, *a. b.* is eighteen inches; the length of the blades to the handle ten inches, but each handle four; the width, *q.* one and three-fourths; the breadth *s. t.* two inches and an half. Theſe ſhears have a diviſion at *c.* and *d.*; but in ſuch a manner that the joinder reaches two inches beyond the hole. This is endeavoured to be ſhewn by *i. k.* and *f. u.* When the ſhears incloſe the ſhank, the diviſions are faſtened by their ſcrew-nails, *g.* as is ſhewn by *u.* and theſe again ſecured by a female-ſcrew, *h.* that they may be put on or taken off by the key, *z.*

§. XXI.

If the ſcrew-nail be found too troubleſome, an iron ſtaple and hook will anſwer nearly as well. Theſe ſhears are placed under the ſcrew or key-hold, and extend far beyond both brims of the hole, and have therefore every deſirable advantage to recommend them. One or two more will be ſufficient.

§. XXII.

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1. The *ſeeker*, fig. 13, is ſeven or eight inches long; *o.* is the ſcrew, *e.* the place of the key; *p.* is a ſpiral point that either takes the broken bit into its cavity, or at leaſt detaches it from the ſide of the hole. One or two of theſe will ſuffice.

§. XIX.

If the *ſeeker* fail, we muſt have recourſe to the *cone-ſcrew*, fig. 14. From *k.* to *l.* it is nine inches long. The aperture, *n. l. o.* is ſix inches wide, and the brim ſharp. It grows narrower to *m.* where is placed a female ſcrew, *x.* It has a ſcrew at *k*, and is faſtened like the reſt juſt below it. As ſoon as the broken bit comes under the mouth of this inſtrument, we work it on until the ſcrew has taken a firm hold, and then quietly draw out the entire. It is neceſſary to have three more of theſe.

§. XX.

There is but one accident more for which we have not already provided: this is

is the falling of the ſhank back into the hole, when we unſcrew any part of it: but, let it be ever ſo long and heavy, it can be ſupported by the cloſed ſhears, fig. 15. Its entire length, *a. b.* is eighteen inches; the length of the blades to the handle ten inches, but each handle four; the width, *q.* one and three-fourths; the breadth *s. t.* two inches and an half. Theſe ſhears have a diviſion at *c.* and *d.*; but in ſuch a manner that the joinder reaches two inches beyond the hole. This is endeavoured to be ſhewn by *i. k.* and *f. u.* When the ſhears incloſe the ſhank, the diviſions are faſtened by their ſcrew-nails, *g.* as is ſhewn by *u.* and theſe again ſecured by a female-ſcrew, *h.* that they may be put on or taken off by the key, *z.*

§. XXI.

If the ſcrew-nail be found too troubleſome, an iron ſtaple and hook will anſwer nearly as well. Theſe ſhears are placed under the ſcrew or key-hold, and extend far beyond both brims of the hole, and have therefore every deſirable advantage to recommend them. One or two more will be ſufficient.

§. XXII.

§. XXII.

The keys, fig. 20 and 16, not only render the ſcrewing off and on more eaſy, but alſo more expeditious. The length, *a. w.* is thirteen inches; the hook, *x. y.* four inches, and its breadth one and three-fourths. By the aſſiſtance of theſe ſhears, the bits may be held by their flat part or hold, whenever it is neceſſary to lengthen or ſhorten the ſhank, or change the ſcoop. It is neceſſary to have one more of theſe than we want for actual uſe.

§. XXIII.

I muſt recommend, once again, to have all theſe inſtruments of exactly the ſame ſize, of good iron, the ſcoops particularly, which ſhould alſo be well ſteeled.

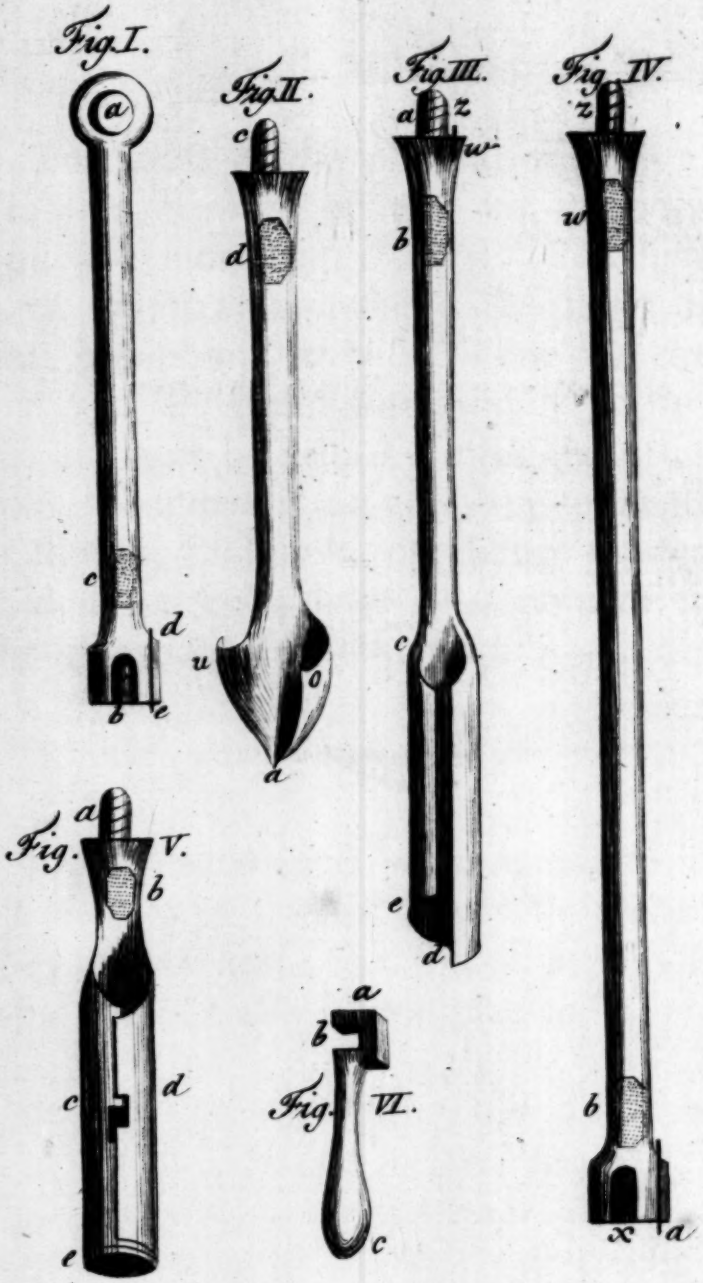
Fig. I.
a
c
d
b
e
Fig. II.
c
d
u
o
a
Fig. III.
a
z
w
b
c
e
d
Fig. IV.
z
w
b
x
a
Fig. V.
a
b
c
d
e
Fig. VI.
a
b
c

PART THE SECOND.

Of the Advantages and Manner of employing the Mine-auger.

SECTION I.

AFTER having fully deſcribed the different bits of this inſtrument, and the mode of joining them, it only remains to ſhew how they ſhould be employed when joined. Beſides preſſing and turning, which are here neceſſary, as when we uſe a common auger, there are a few other managements requiſite, and theſe I ſhall now explain.

§. II.

Where from the uſual indices, or any other circumſtance, we ſuſpect the preſence of a mine, and wiſh to be aſſured of it by trial, as alſo of the length, breadth or depth of the metallic vein, we begin with one bit of the auger only, to aſcertain with greater certainty the intended direction: the handle is then put through the eye of the firſt ſhank-bit, and the clay-ſcoop, plate I. fig. 4. ſcrewed on in looſe earth; but, in a

denſer, it muſt be the ſpiral-ſcoop, fig. 3. When the ſcoop is filled with loam, ſand, &c. it is withdrawn and emptied, a ſhank-bit, two feet longer put on, and the boring continued until the ſcoop is again filled; it is then withdrawn, emptied, a ſhank-bit four feet longer put on, next five, and laſtly a fathom.

§. III.

When ſtones are met with, it is alſo neceſſary to take out the auger, and, as circumſtances ſhall direct, to change the clay or ſpiral ſcoop, for the firſt or ſecond ſpecies of the ſtone-borer: but, if the paſſage be not all through ſtone, uſe the crow, as at §. XII. part the firſt. In uſing this, however, it is evidently needleſs to turn it round like the other borers; it muſt, on the contrary, be lifted up, then ſuffered to recoil with the whole power of its gravity, by which means the ſtone will be ſhivered. Another miner ſhould direct the crow to that ſide on which it is perceived to be prominent. It would alſo be proper to pour water into the hole during the uſe of the five laſt inſtruments, as well to cool them, which become very hot, as to ſoften the earth.

§. IV.

§. IV.

When the miner perceives the ſtone is pounded, he ſhould apply the ſhovel-ſcoop inſtead of the crow, turn it a few times round, and proceed as before directed.

§. V.

By the acceſſion of ſo many bits, the auger is already grown too heavy to be managed by the ſingle hands of the miner; ſome machines are therefore requiſite to aſſiſt him. They are the following.

§. VI.

The firſt is repreſented by fig. 18. *a. c.* it denotes a poſt eighteen feet high, ſunk in the ground about four feet one-half. In the middle it is hollowed, *b.* to admit a lever to paſs through it. In the fore part it has two rows of holes, in which iron pins are alternately fixed to ſupport the lever, which from *b.* to *c.* is fifteen or ſixteen feet long. A ſpace left by two prongs at the end of this lever is two inches, the prongs themſelves are each one inch thick; into this ſpace is taken the part of the firſt

ſhank-bit comprehended between its protuberances. To prevent the auger from falling out of the fork of the lever, an iron pin muſt be thruſt through an hole in the fore part of the prongs: by help of this lever, the auger can be raiſed at will, and the application of it is peculiarly proper whenever we want to uſe the crow.

§. VII.

The ſecond. Whereas the lower bit muſt indiſpenſably be often changed, this machine is contrived to draw out the whole ſhank in a piece; for unſcrewing each ſeparate bit would be attended with much trouble, and, in any other manner, hands alone could not effect the extractions. A poſt, fig. 20, is fixed in the ground; its height to *g*. may be eight, nine, ten, or more fathoms, for the higher the better, becauſe the ſhank can be in one piece, of a proportional length to the elevation of the poſt. One ſide of the poſt is ſtuck with rundles for the convenience of the miners aſcending and fixing on both the pully and cable, *n*. The draw-hook is put through the cable at *o*. the firſt ſhank-bit holding the handle, unſcrewed, and this put on.

§. VIII.

§. VIII.

When things are thus prepared, the miner applies himſelf to the windlaſs, and raiſes the borer by rolling on the rope. When it can be raiſed no higher, the other puts the ſhears, *b.* to the flat part of the ſhank, and acroſs the hole at *b.* ſo as to hinder the remainder of the ſhank in the hole from falling down; he unſcrews with the key, *r. s.*; carries it aſide in the direction, *x. y.*; and lays it readily on the ground. The draw-hook is again ſcrewed to ſuch part of the ſhank as may have been left behind, and this drawn out in like manner, until we come to the lower bit we want to change. After having done ſo, the ſhank is again united, and the work proſecuted in the manner aforeſaid.

§. IX.

We have now ſhewn the way of boring downwards, and ſhall proceed to that of boring horizontally. See fig. 19. At the ſpot, *g.* where you wiſh to examine, bore at firſt in the due direction about a fathom, then put in the auger, made for the preſent only out of the ſcoop and firſt ſhank-bit.

In

In this proceſs more people are requiſite than in the other; one man at leaſt is neceſſary at each end of the handle, to give the inſtrument the impulſe, that in perpendicular boring is ſupplied by its own gravity. Whilſt we uſe but the clay or ſpiral borer, or the crow, the work is expeditious; but the ſtone-borer takes up a length of time, and needs the full exertion of the miners. The lever is greatly conducive to it: reſting on the block *b.* and holding the firſt-ſhank-bit between its prongs, and being at the ſame time moveable at its other end by a rope, *h. i.* when this is raiſed it impels the auger forward.

§. X.

It would prove very uſeful to the labourers to have a ſhed built over the auger and work-place, at the top of which the rope, *h. i.* can be ſecured. On one ſide at leaſt, *c.* it muſt be left open, for if the plain be at all extenſive, without unſcrewing part of the auger, it may be withdrawn, the lower bit changed, and again quickly replaced by means of the rope and lever. Is it required to bore at *e.* or *f.* the ſoil muſt be dug to ſuch a depth as equals the diſtance from *f.* or *e.* to *g.*

The

The pit muſt be at leaſt wide enough to contain the work-men: as to its length, the greater the better; for in proportion to it the auger may, without the trouble of unſcrewing, be withdrawn and replaced. In regard to other circumſtances, a miner will readily know how to aſſiſt himſelf.

§. XI.

To bore up, fig. 21. is not impoſſible, provided only there be a previous hole of a fathom, where the auger is entered and ſecured, *b. c.* in the forks of a double lever. A miner takes the handle, and turns the auger; two others, by means of the lever, *b. c.* preſs it vigorouſly up, that the borer may take hold. In clay and mould, and in working with the crow, they both at *c. b.* ſtrike it forward, and thereby promote the work conſiderably. At *d.* is a hole, the deeper the better; now when it is neceſſary to change, the miner at *b.* holds his lever ſo firm that the auger cannot deſcend; the other at *o.* withdraws his lever, and *b.* yields with his own, till the auger deſcends to *c.* when the other miner truſts his lever above, and yields as the former. The auger ſinks in this manner more and more into the hole *d.* and ſo far as the depth

depth of this reaches, it is unneceſſary to unſcrew it. By a ſimilar change of the levers, we raiſe it again, when the lower part is changed. But where a hole cannot be made without a certain expence, there is no way left but the more circuitous and laborious one of unſcrewing the ſhank, bit after bit.

§. XII.

In boring upwards, it is as needleſs as impracticable to pour water; and it has beſides this advantage, that the bore-meal and ſludge come away of themſelves. They muſt be prevented, by means of a cheſt, from hurting or incommoding the miner.

§. XIII.

In reſpect of the work to be performed by the mine-auger, nothing is left unſaid: The handle and ſhank, the bits to examine and to bore, the keys, ſcrews, &c. have been all deſcribed; in my opinion, then, nothing remains, but briefly to ſtate the utility of the inſtrument.

PART

The borer of Mersennus

Fig. A.

Fig. VIII.

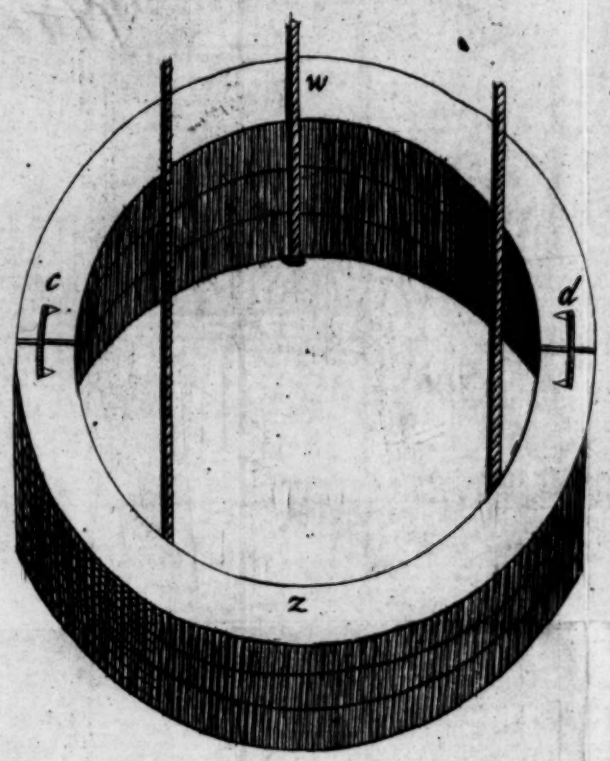

Fig. V.

Fig. VI.

Fig. I.

Fig. II.

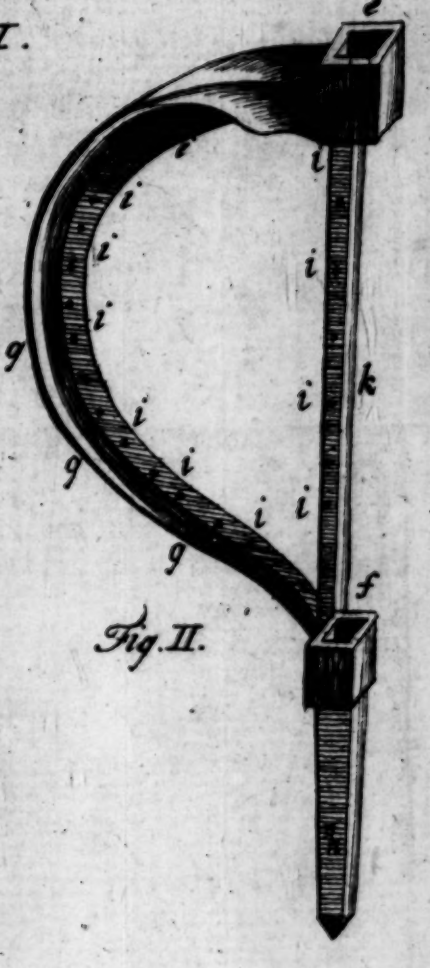

Fig. VII.

Fig. III.

Fig. IV.

PART THE THIRD.

Of the Advantages of the Mine-auger.

SECTION I.

WHOEVER attends to the foregoing pages and annexed plate, muſt acknowledge, though ever ſo little acquainted with mining, that the management of this inſtrument is very eaſy; its utility being at the ſame time ſo evident, I'll not dwell upon it long, to avoid the cenſure of the latin proverb, *laus propria ſordet.*

§. II.

If we conſider the vaſt expence it ſaves in ſearching for mines, we may venture to affirm, it is indiſpenſably neceſſary in all ſuch undertakings: whether we mean to explore new veins and minerals to any extent, their elevation or depreſſion, and their comparative value at different diſtances. It frequently brings to light the moſt valuable kinds of clay, where they were not at all ſuſpected: light-holes can be made

by it any where: and, in a word, every thing neceſſary to our purpoſe diſcovered and accompliſhed.

§. III.

It is equally productive of œconomical utility:

1ſt. When we wiſh to ſink a well, we may diſcover by it how deep the vein of water lies, if it be copious or not, ſoft or hard, pure or corrupt, and whence it proceeds.

2d. It may be uſed to pierce ponds or marſhes, conduct away the water, and leave the ſoil fit for cultivation.

3d. To bore cellars that overflow at certain ſeaſons, and convey this water to any other place it may be wanting.

4th. To examine the lower ſtrata of any field, to know if it contain coal, gips, marl, chalk, &c.

5th. The architect may diſcover with it whether there be a ſure foundation where he intends to build; for its unequal firmneſs is moſtly ever the cauſe of the building's ſinking.

6th,

6th. All ſorts of drains and ſoakers can be made with it in yards and gardens, at very little coſt: There are many uſeful purpoſes beſides, to which it can be applied, but theſe will occur of themſelves to an induſtrious huſbandman.

§. IV.

In military operations, it can be often more ſerviceable than ſome regiments of the beſt ſoldiers.

1ſt. During a ſiege, if the enemy ſhould deprive the garriſon of water, and reduce it to the melancholy alternative of dying of thirſt, or delivering up the town; both may be prevented by the mine-auger; water in a manner dug, and conducted from any diſtance to the reſervoir. In the field likewiſe it can ſupply the want of water.

2d. If we know in what quarter of the camp the Commander in Chief's tent is, though at the diſtance of ſome hundred fathoms, we may blow him up, together with a great deal of the camp and batteries; and thus gain more than by winning a bloody battle.

3d. In beſieging a town, it will ſerve (eſpecially if the lower part be larger) to blow up the magazines, or at leaſt part of the walls.

4th. Mines can happily be diſcovered by it, and overflown with water to their utter ruin.

5th. Overflown trenches may be emptied by it; and many other great advantages obtained.

Laſtly, I muſt juſt obſerve, for the ſake of thoſe who may think the expence of the inſtrument too heavy, that for twenty fathoms they amount to no more than fifty rix dollars; whereas one gallery will often coſt a thouſand. The other expences cannot be ſo readily determined, as they are regulated by the greater or leſſer depth to be bored, and the nature of the ſtrata.

DESCRIPTION

OF A

BORER FOR THE FARMER.

SECTION I.

FOR the farmer's ſake, who is unwilling, and indeed need not go to the ſuperfluous expence of having a Mine-auger, I'll deſcribe another, which he may procure at a moderate price; and which will nevertheleſs be very ſerviceable in many inſtances; but eſpecially in making him acquainted with the nature of the ſoil.

§. II.

It is ſeldom neceſſary to make this auger or *Earth-borer* more than ſix or eight yards long; and it conſiſts, like the mine-auger, of various bits, ſucceſſively ſcrewed together: they are repreſented, plate II. in their proper proportions.

§. III.

§. III.

The firſt ſhank-bit, fig. 1. has at top a ſtrong eye, *a.* two inches wide, through which you put a ſtrong handle of wood, about two feet long: at the bottom it has a female-ſcrew, *b.* to receive the following bits. The ſhank itſelf is round, except at *c.* where it is flattened to give a hold to the key. *e.* is a pin which is thruſt in at *d.* and paſſes at *e.* from the firſt ſhank-bit into the ſecond, ſo far as to prevent either from unſcrewing. The length of the ſhank-bit from *a.* to *b.* is three-fourths of a yard; its diameter one inch.

§. IV.

Fig. 2. is the ſecond ſhank-bit; at *c.* it has a male-ſcrew, at *b.* it is compreſſed; below the inſtrument is flat like a ſpade, with both edges bent in contrary directions, and well whetted *o.* and *u.* The breadth is three inches, the thickneſs half an inch, or a little more, and the length three quarters of a yard.

§. V.

§. V.

The third bit, fig. 3. is the borer itſelf, and that which comes moſt frequently into uſe. Like the ſecond bit it has a male-ſcrew at *a*. At *z*. is the pin, which, as in fig. 2. 4. 5. does not penetrate quite through, but ſtops at *w*. Below the ſcrew at *b*. is the *key-hold:* From *b*. to *c*. the bit is round, and one inch in diameter: from *c*. down it is hollow, with a fiſſure in the middle, by which the earth is received. Below at *d*. it has a pointed edge, which to *e*. turns ſpirally, and is well whetted. The whole length of this inſtrument is one yard.

§. VI.

Fig. 4. is a middle-ſhank which has in like manner a male-ſcrew at *z*. Below the ſcrew, the bit is as uſual one inch and a half thick, and compreſſed at *w*. But from *w*. to *b*. it is like the other ſhanks, only one inch. At *b*. it has another key-hold. At *x*. as above it is one inch and a half thick, and contains a female-ſcrew into which the borer, fig. 3. or 5. or elſe, in caſe of boring deeper, another middle-ſhank is ſcrewed. *a*. is the pin, ſo often mentioned,

mentioned, to prevent the unſcrewing of the bits. The entire length of this inſtrument, from *z.* to *x.* is one yard and one-fourth; but it may be made of a yard and half.

§. VII.

The inſtrument repreſented by fig. 5. is a ſand-borer, which has its ſcrew at *a.* and its key-hold at *b.*: *c. d.* repreſents one ſide lapping over the other; the ſide *d.* is very well edged, and in the middle they have a quadrangular hole. Below it has a bottom obliquely opened from *e.* to the other ſide? which, together with the longitudinal fiſſure, ſcrapes up and catches the ſand. This inſtrument is three-fourths of a yard in length.

§. VIII.

Fig. 6. repreſents a key by which the aforeſaid bits are ſcrewed together. Its length from *a.* to *c.* is one-fourth of a yard. The breadth of the indenture, *b.* is not quite an inch, and muſt be exactly fitted to the key-hold. Any thing more belonging to this key, may be eaſily known from the figure.

§. IX.

§. IX.

The mode of uſing the inſtrument is this: The *bit*, fig. 2. by help of the key, fig. 6. is ſcrewed on the firſt ſhank-bit, and the ſod cut up. When this is done, fig. 3. is put in its place, and the hole continued. At every foot that is bored, the inſtrument muſt be drawn up again, to examine the quality of the earth. When we have bored the full length of theſe two *bits*, the middle-ſhank-bit, fig. 4. is put between them, and the auger lengthened in a ſimilar manner to any diſtance we may deſire to bore.

§. X.

But if the farmer, in examining the qualities of his ſoil, ſhould meet with a ſandy ſtratum; the inſtrument, fig. 3. is uſeleſs to him, for it will not take up the ſand. In that caſe, fix on the inſtrument fig. 5. This ſcrapes up and catches the ſand, and from the nature of its lapped ſides, will not let it fall out. When the paſſage is cleared through it, the other ſtrata may be examined as before.

§. XI.

All theſe bits ſhould be made of good iron. An earth-borer of eight yards will weigh about thirty-two pounds, and is, of conſequence, eaſily managed by one man. He can with great eaſe examine the ſtrata to a depth of ſeven or eight yards in an hour, which is more than ten men could do with ſpades in an entire day. Moreover, it does no damage to the ſod. It is plain then that this inſtrument may, in a variety of ways, be uſeful to the farmer; as

§. XII.

1ſt. By making him acquainted with the contents and interior conſtitution of his ground, and the means of improving it; viz. when a field conſiſts of ſand at its ſurface, to find clay; and when on the contrary it conſiſts of clay, to find ſand.

2d. In building, it is neceſſary to examine the foundation, and know whether it be firm on one ſide, and looſe on the other, which would inevitably occaſion the building to ſink.

3d. It

3d. It is very convenient in ſeeking for a ſpring.

4th. In ſeeking for marl; whoſe great advantages are ſo well known.

5th. All ſorts of clay; as porcelain-clay, brick-clay, refractory-clay for bricks, retorts and the Waldenbourg veſſels, fullers-earth, and pipe-clay, &c. With many other uſeful earths, which I ſhould rather call treaſures, and which, though devoutly wiſhed for, often remain, through want of a proper inſtrument, undiſcovered in the field, uſeleſs to the owner, and unprofitable to the ſtate.

DESCRIPTION

OF THE

WELL-BORER.

THE Well-borer is an inſtrument with which a wide and deep hole is made in the earth, which immediately becomes a well, if any water be underneath. It differs from the mine-auger in being capable

1ſt. Of making a hole two or three yards in diameter; whereas the mine-auger can only make one make one of ſix inches.

2d. Of boring only through ſand, ſoft clay, or mud, and not through ſtone.

It is uncertain who firſt invented or employed it; but it has been uſed very early in Holland, to diſcover peat under water, and to clear harbours from ſlime and ſand. On this latter principle, *Cornelius Meger* turned it to the very uſeful purpoſes of making rivers navigable.

Beſides

Beſides this, the only account we have of it, is from *Merſennus*, in his phænomena hydraulica, p. 219. where he deſcribes the ſinking of a well in Amſterdam 232 feet deep; an accurate account of which he had from Mr. Hugens: as theſe circumſtances are ſomewhat curious, I'll give a literal tranſlation of the latin original.

Marinus Merſennus' account of the Well made with this inſtrument in Amſterdam.

" The depth of the well was 232 feet: " the earths met with in the courſe of " digging, and the thickneſs of each ſtra- " tum, were as follows:

	Feet.
" Garden earth - - -	7
" Turf - - - -	9
" Loam - - - -	9
" Sand - - -	8
" Clay - - - - -	4
" Loam - - -	10
" Clay - - -	4
" Sand, ſuch as the inhabitants of Am- " ſterdam ſink their piles for build- " ing in - - -	10
" Loam - - -	2
" White Sand - - -	4

" Dry

" Dry Clay - - - 5
" Mixed Clay - - - 1
" Sand - - - 14
" Sandy Loam - - 3
" Sand mixed with Loam - 5
" Sand mixed with Cockles - 4

" After theſe 99 feet, followed 102 feet " of loam, and laſtly 31 feet of ſand. Here " the well ended, whoſe depth was 32 feet " more than the height of the tower of " Amſterdam.

DESCRIPTION *of the* INSTRUMENT, *fig. A.*

" *b. c.* is the back, one inch thick, and " three inches broad; *f. h. i.* a ſemi- " circular iron, the edge of which, *h. i.* " is whetted for cutting; between *f. h. i.* " is a net; the ſemi-diameter of this " half-circle is eleven inches. If the " clay be tenacious, this will take out a " clod eleven inches broad, and two inches " and a quarter high; but if it be a ſandy " earth, it will ſcarcely take out one quar- " ter. The net is for holding in the ſand, " and ſo cloſe that water can ſcarcely paſs " through it. Nine or ten men are requi- " ſite for working this machine, and wedg- " ing the bits ſucceſſively into one another.

" When-

" Whenever it is neceſſary to draw up the
" borer, a rope, *f. m.* is tied to it, and
" brought acroſs a beam that is ſupported
" over the hole; a man pulls then at *m*,
" and by this means raiſes it. The borer
" is turned by means of the croſs beam,
" *g. b.* its height, *c. k.* is three feet one-
" fourth; and as the bit *b. c.* is ſix feet
" long, *b. k.* is nine feet one-fourth. The
" ſame is to be underſtood of all the other
" bits. The croſs beam, *g. l.* is to be put
" through each of the holes, *d. n. c.* that
" the borer may be turned in every height.
" Each bit is ſplit at the end, *b. q. r.* and
" has a ferrule; into this fiſſure the next
" bit is thruſt, and retained there by an
" iron pin. In this way all the bits are
" joined; but it is not neceſſary they ſhould
" be all limited to ſix feet; they may be
" even ten or twelve. If the bits be made
" ſquare, they ſhould have half a foot in
" breadth. So ſoon as the well is dug, a
" water-cheſt may be prepared, out of
" which, by means of a pump, as much
" water may be drawn as we want, or as
" the well can ſupply. To prevent the
" borer from being incloſed by a fall of
" ſludge and ſand from the ſides, as hap-
" pened in Amſterdam, the hole ſhould be
" filled with water, which will ſupport
" them.

" them. This well was ſunk in the ſpace " of thirty-two days and thirteen nights; " and it frequently happened that during " the time the labourers were at their " meals, the water roſe from twenty to " thirty feet." So far *Merſennus.*

As the figure of Merſennus' Borer is very imperfect, and has beſides many faults and inconveniences, I have not only added a more complete one, but alſo ſhewn how a well might be ſunk in looſe ſand, and walled at the ſame time from top to bottom.

Our Author's IMPROVEMENT *on this* WELL-BORER.

SECTION I.

FIG. 1. is the lower bit of this borer. *a.* a male-ſcrew by which it is united to the reſt. From *b. c.* to *e.* it is round, but thence downward ſquare, and three and an half inches thick. At *d.* is the key-hold;

hold; *z.* is the pin mentioned in the deſcription of the Mine-auger, which will ſerve inſtead of the ſcrew-pin. From the ſcrew *a.* to the point, it is ſix feet long. At *e.* and *f.* it has a wooden ſocket, as repreſented by fig. 2. through which the ſhank paſſes; and is ſecured at the holes *e. f.* by the ſcrew-pin *g. h.* fig. 6.; or if this be thought too troubleſome, by the pin *w.* and the hold-faſt *z.* From *e.* to *g.* and down to *f.* this inſtrument is arched; the outward ſide of which, *g.* is ſharp, and to the inſide is tied the net. At *h.* is the point; from *f.* where it is two inches thick, it gradually diminiſhes to half an inch. In the ſituation here drawn, it is fit for boring, only with the addition of the ſhank-bits, fig. 3. or 4.

§. II.

Fig. 2. is the borer without the ſhank or net; *e. f.* are the ſockets; *g. g. g.* is the whetted arch that cuts, and throws the earth into the net. *i. i. i.* are the holes to which the net is tied; *k.* is an iron with holes in which to faſten it likewiſe: In fig. 1. this iron is behind the ſhank. The *radius* of this borer is two feet. The net ſhould be made of the beſt twine, and ſo cloſe as to retain the fineſt ſand.

The borer has but this ſingle under-bit; but, as it requires to be occaſionally lengthened, ſhortened and withdrawn, ſhanks, ſhears, keys and levers are all neceſſary parts of the apparatus.

§. III.

Fig. 3. is the firſt-ſhank-bit which has at top a ſtrong eye to take in the handle; *a. b.* are two knobs for holding a rope, but here it will be ſeldom found requiſite. *c.* is the key-hold; the thickneſs, *e. f.* is three inches and an half. *d.* is the female-ſcrew, in which the borer, fig. 1. or another ſhank-bit is ſcrewed.

§. IV.

Fig. 4. is a ſhank like that deſcribed when treating of the Mine-auger; *c.* and *f.* are two key-holds; *g.* and *q.* are the two ſcrews.

§. V.

Fig. 5. is the draw-hook for pulling out the borer, when it becomes neceſſary to empty the net. *c.* is the crook, *b.* the key-hold, *a.* the ſcrew, and *z.* the pin.

§. VI.

Fig. 6. ſhews the ſcrew-pin and hold-faſt already deſcribed in treating of the Mine-auger.

§. VII.

§. VII.

The entire management of the Well-borer may be eaſily collected from the foregoing deſcription of the Mine-auger. I have therefore deemed it ſuperfluous to repreſent in additional plates the ſhears, keys, and lever neceſſary for lengthening, ſhortening, ſcrewing off and on, withdrawing and returning the borer. It only remains then to ſhew how a well to be bored by this inſtrument in mere ſand, may be walled from top to bottom.

§. VIII.

Firſt take two ſtones that give exactly the periphery of the well; each of them muſt be half its circumference, as *w. z.* fig. 8.; and *w.* fig. 7. They muſt be bound together by iron hooks, *d. c.* fig. 8. Then a circle of ſtrong wood of the ſame dimenſions with the aforeſaid ſtone; this is laid on the hole, and made the baſis of the building. But, that they may all remain in their proper order, three or four ropes, fig. 8. are bound to the wood, and faſtened again above the earth, ſo as to let this, with the ſtones upon it, gently down; for, when the borer, fig. 7. takes away the ſand in the middle, *w. w.* the other, *x. y.* ſinks after.

§. IX.

§. IX.

To prevent any water from inſinuating itſelf between the junctures of the ſtones, I will here add a receipt for a moſt excellent cement:

Quench quick-lime with vinegar, mix with it about one-half of iron-filings; take of this mixture a given quantity, and add to it half as much freſh cow-dung; work the whole well together, and it is fit for uſe.

This cement grows as hard as ſtone, yet rather dilates than contracts, and abſolutely precludes the acceſs of water. We muſt uſe hewn ſtone to about the middle of the well, but the upper part may conſiſt of brick.

§. X.

All I have further to add, is a ſincere wiſh that this little work may attain the end of its author, which is no other than to promote the good of my country, by facilitating the means of working its mines.

F I N I S.